Higher Electricity

Past Paper Answers

Contents

Higher Electricity Answers

Band Theory and Conductivity

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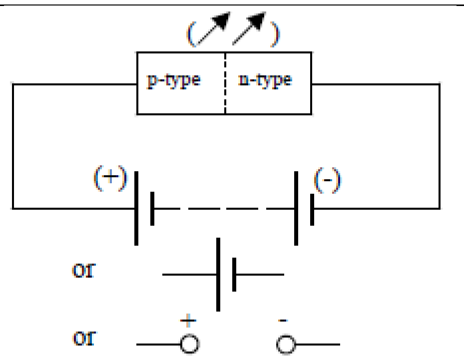
15a)	Decreases	(1)
15bi)	The electrons and holes combine at the junction which causes photons to be emitted.	(1) (1)
15bii)	$m\lambda = d\sin\theta$ $2 \times \lambda = 5 \times 10^{-6} \times \sin(11)$ $\lambda = 4.77 \times 10^{-7}$ m	(1) (1) (1)
16a)	 *Must have negative terminal of power source at same side as n-type.*	(1)
16b)	Electrons and holes combine (at the junction) causing photons to be emitted.	(1) (1)
16ci)	$E = hf$ $v = f\lambda$ (*both equations*) $3.68 \times 10^{-19} = 6.63 \times 10^{-34} \times f$ $3 \times 10^{8} = 5.55\ldots \times 10^{14} \times \lambda$ $f = 5.55\ldots \times 10^{14}$ Hz $\lambda = 5.40 \times 10^{-7}$ m	(1) *both eq.* (1), (1) sub. (1) final ans.
16cii)	$E = QV$ $3.68 \times 10^{-19} = 1.6 \times 10^{-19} \times V$ $V = 2.3$ V	(1) (1) (1)
17ai)	Electrons and holes combine at the junction releasing photons	(1) (1)
17aiiA)	$v = f\lambda$ $3 \times 10^{8} = 6.7 \times 10^{14} \times \lambda$ $\lambda = 4.48 \times 10^{-7}$ m	(1) (1) (1)

17aiiB)	Blue/Blue-violet/Blue-indigo (*any of these answers*)	(1)
17aiii)	E = hf E = 6.63 x 10^{-34} x 6.7 x 10^{14} E = 4.44 x 10^{-19} J Caesium and Strontium (as a photon's energy is greater than the work function of these two metals). *Calculating the frequency required to eject photoelectrons for all of the metals is also an acceptable method of finding the answer.*	(1) (1) (1) (1)
17b)	mλ = dsinθ 2 x 6.35 x 10^{-7} = 5 x 10^{-6} x sinθ θ = 14.7^o	(1) (1) (1)
18a)	Decreases	(1)
18bi)	Photoconductive mode	(1)
18bii)	More photons of light are landing on the junction <u>per second</u> this cause more electron-hole pairs to be produced.	(1) (1)
18c)	I = k/d^2 I = k/d^2 3 x 10^{-6} = k/1.2^2 I = 4.32 x 10^{-6}/0.8^2 k = 4.32 x 10^{-6} I = 6.75 x 10^{-6} A *Using $I_1d_1^2 = I_2d_2^2$ is also an acceptable method of finding the answer*.	(1) equation (1) all sub. (1) final ans.
19a)	The band gap between the valence band and the conduction band is small. If electrons are excited into the conduction band (by crossing the small band gap) then charge can flow.	(1) (1)
19b)	Any <u>single</u> value higher than green's 2.0 V but less than 2.8 V, e.g. <u>2.2 V</u>.	(1)
19c)	v = fλ E = hf (*for both equations*) 3 x 10^8 = f x 850 x 10^{-9} E = 6.63 x 10^{-34} x 3.52… x 10^{14} f = 3.52… x 10^{14} (Hz) E = 2.34 x 10^{-19} J	(1) (1), (1) sub. (1) final ans.
20a)	X = insulator Y = semiconductor Z = conductor	(1)
20b)	The energy gap/band gap (between the valence and conduction bands) is small. Some electrons have enough energy to move from the valence to the conduction band.	(1) (1)
20c)	Increases	

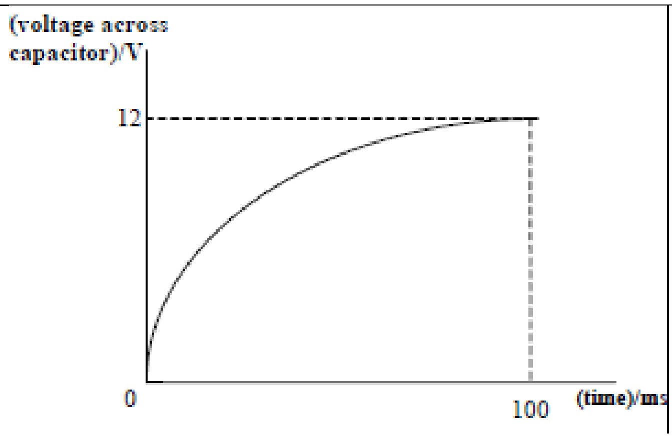
21a)	I = 35 mA (from the graph) (*this can be in the substitution*) P = IV P = 0.074 W *Using 34.5 mA is acceptable too, giving the final answer as P = 0.073 W.*	(1) (1) (1)
21b)	Greater number of photons <u>per second</u>. *The answer must imply a greater <u>rate</u> of photons.*	(1)
22.	**Show teacher if possible** *Answer <u>could</u> include correct information on electrons and holes recombining at the junction to release photons; a certain voltage being needed across the LED dependent on the colour of photons being emitted; relevant information or examples on E = QV, E = hf and v = fλ; reference to energy/volts being lost due to internal resistance in the battery; the LED needing to be forward biased to emit photons; electrons moving from the conduction band to combine with holes in the valence band for photons to be released.* *Doping is <u>not</u> really relevant to the student's statement so unlikely to gain marks.*	(3)

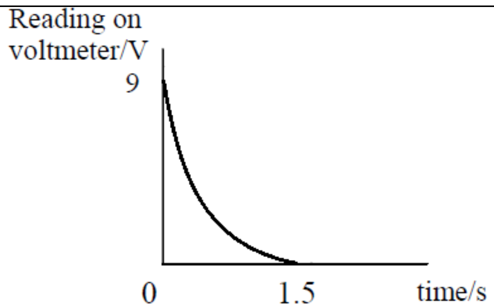
Practical Circuits

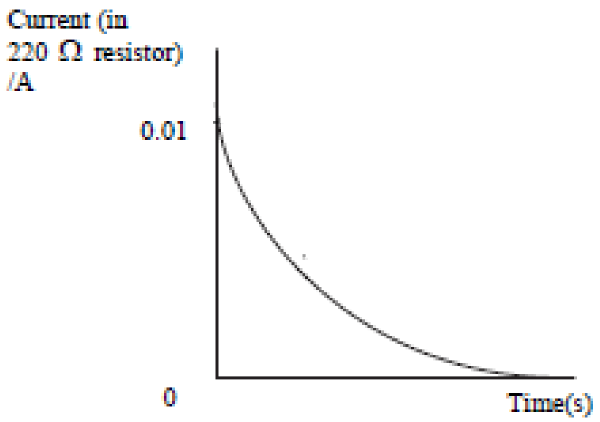
1. D	2. C	3. C	4. B	5. A	6. C
7. A	8. B	9. B	10. B	11. D	12. D
13. C	14. E	15. D	16. B		

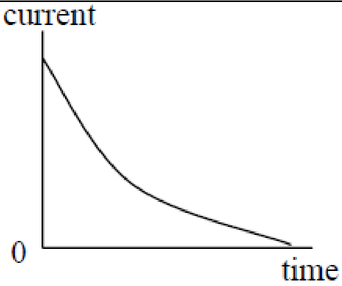
Capacitance

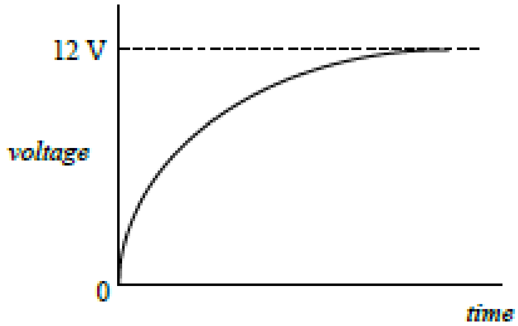
1. B	2. A	3. C	4. C	5. B	6. E
7. D	8. B	9. B	10. E	11. D	12. D
13. E					

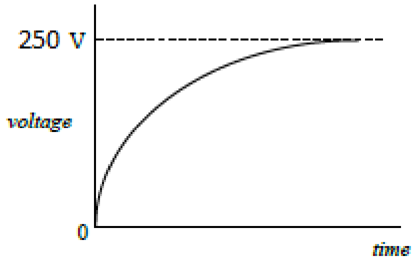
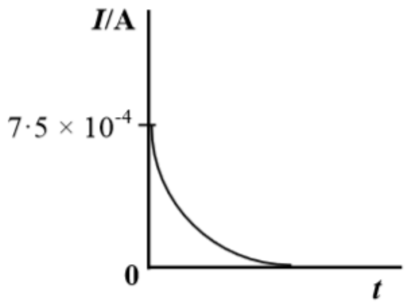
14ai)	V = IR $6 = 1.5 \times 10^{3} \times R$ $I = 4 \times 10^{-3}$ A	(1) (1) (1)
14aii)	$E = ½CV^{2}$ $E = ½ \times 470 \times 10^{-6} \times 6^{2}$ $E = 8.46 \times 10^{-3}$ J	(1) (1) (1)
14aiii)	Increase the supply voltage.	(1)
14b)	E = hf $E = 6.63 \times 10^{-34} \times 5.8 \times 10^{14}$ $E = 3.84… \times 10^{-19}$ J Total number of photons = total energy ÷ energy of one photon Total number of photons = $6.35 \times 10^{-3} \div 3.84… \times 10^{-19}$ Total number of photons = $\underline{1.65 \times 10^{16}}$ (photons)	(1) (1) (1) (1)
15a)	6 V	(1)
15b)	$E = ½CV^{2}$ $E = ½ \times 2000 \times 10^{-6} \times 6^{2}$ $E = 3.6 \times 10^{-2}$ J	(1) (1) (1)
15c)	V = IR $6 = 7.5 \times 10^{-3} \times R$ R = 800 Ω	(1) (1) (1)
16a)	 (*Shape*) (*Numbers including origin (zero), units and axis titles*)	 (1) (1)

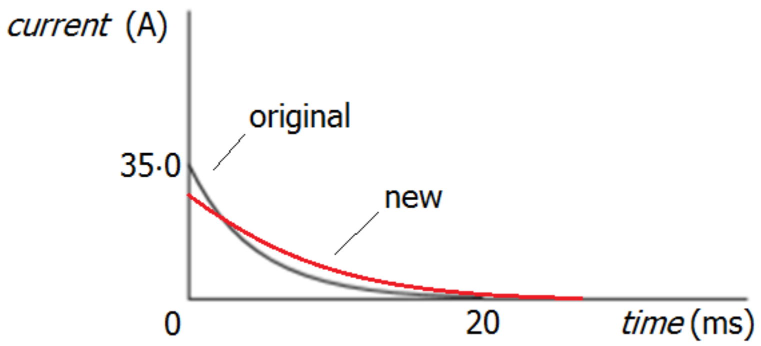
16bi)	V = IR V = 20 x 10^{-3} x 400 V = 8 V (across the resistor) V = 12 – 8 (*if missed but final answer is still 4 V then full marks given*) V = 4 V (across the capacitor)	 (1) (1) (1) (1)
16bii)	E = ½CV^2 E = ½ x 100 x 10^{-6} x 4^2 E = 8 x 10^{-4} J	(1) (1) (1)
16c)	Less than 100 μF as the time taken to charge is smaller. *No <u>attempt</u> to explain means 0 marks, even if you said less than 100 μF, "**must** explain your answer".*	(1) (1)
17ai)	 (*Shape*) (*Numbers including origin (zero), units and axis titles*)	 (1) (1)
17aii)	The time taken will be longer as the larger resistance causes a smaller current in the circuit.	(1) (1)
17aiii)	9 – 4 = <u>5 V</u> (*this can be in the substitution*) C = Q/V 2200 x 10^{-6} = Q/5 Q = 0.011 C	(1) (1) (1) (1)
17bi)	E = ½CV^2 E = ½ x 2200 x 10^{-6} x 9^2 E = 8.91 x 10^{-2} J	(1) (1) (1)
17bii)	V = IR 9 = I x 100 x 10^3 I = 9 x 10^{-5} A	(1) (1) (1)

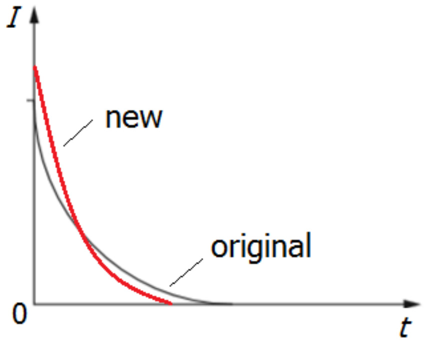
18a)	$V_1 = \left(\frac{R_1}{R_1 + R_2}\right) V_s$ $V_1 = \left(\frac{220}{220+680}\right) \times 9$ V_1 = 2.2 V *Other suitable methods to get the same answer with units is acceptable.*	(1) (1) (1)
18bi)	The more charge that builds up on the capacitor the more energy required to overcome the repulsion.	(1)
18bii)	2.2 V (*or consistent with your answer to 18a))*	(1)
18biii)	$E = ½CV^2$ $E = ½ \times 33 \times 10^{-6} \times 2.2^2$ $E = 7.99 \times 10^{-5}$ J *Voltage used must be consistent with your answer to 18bii) to get the second and third marks.*	(1) (1) (1)
18biv)	 (*Shape*) (*Numbers including origin (zero), units and axis titles*)	(1) (1)
19a)	V = IR $12 = I \times 480 \times 10^3$ $I = 2.5 \times 10^{-5}$ A	(1) (1) (1)
19b)	12 – 3.8 = <u>8.2 V</u> (*this can be in the substitution*) C = Q/V 2200×10^{-6} = Q/8.2 Q = 0.018 C	(1) (1) (1) (1)

19c)	$E = \frac{1}{2}CV^2$ $E = \frac{1}{2} \times 2200 \times 10^{-6} \times 12^2$ $E = 0.158$ J	(1) (1) (1)
20a)	The amount of charge stored per volt.	(1)
20bi)	(12 – 8.6 =) <u>3.4 V</u>	(1)
20bii)	$V = IR$ $3.4 = 1.6 \times 10^{-3} \times R$ R = 2130 Ω (or 2125 Ω) *Voltage used must be consistent with your answer to 18bii) to get the second and third marks.*	(1) (1) (1)
20c)	Less than as the current in the circuit has increased due to the total resistance decreasing.	(1) (1)
21a)	 *curving downwards*	(1)
21b)	$V = IR$ $V = 5 \times 10^{-3} \times 500$ V = 2.5 V (across the resistor) V = 12 – 2.5 (*if missed but final answer is still 9.5 V then full marks*) V = 9.5 V (across the capacitor)	 (1) (1) (1) (1)
21c)	$E = \frac{1}{2}CV^2$ $E = \frac{1}{2} \times 47 \times 10^{-6} \times 12^2$ $E = 3.38 \times 10^{-3}$ J	(1) (1) (1)
21d)	No effect the capacitance and maximum voltage are unchanged. *Look at the previous equation. If C and V are still the same numbers as before then E would calculate to be the same number.*	(1) (1)
22a)	200×10^{-6} coulombs of charge stored per volt. *or* 200 μC of charge stored per volt	(1)

22bi)	V = IR $12 = I \times 1.4 \times 10^3$ $I = 8.57 \times 10^{-3}$ A	(1) (1) (1)
22bii)	$E = ½CV^2$ $E = ½ \times 200 \times 10^{-6} \times 12^2$ E = 0.0144 J $E = ½CV^2$ $E = ½ \times 200 \times 10^{-6} \times 4^2$ E = 0.0016 J Difference = 0.0128 J	(1) equation (1) both sub. (1) both ans. (1) final ans.
23a)	 (*Shape*) (*Numbers with origin (zero), units and axis titles*)	 (1) (1)
23b)	V = IR $12 = 2 \times 10^{-3} \times R$ R = 6000 Ω	
23ci)	The maximum voltage and the resistance of the resistor is still the same. *Look at the previous equation. If V and R are still the same values then the value of I must still be the same.*	(1)
23cii)	Less than as the time take to fully charge is shorter. *No <u>attempt</u> to explain means 0 marks, even if you said less than 100 μF "**must** explain your answer".*	(1) (1)
24ai)	V = IR $250 = I \times 15 \times 10^3$ I = 0.0167 A	(1) (1) (1)

24aii)	 (*Shape*) (*Numbers with origin (zero), units and axis titles*)	(1) (1)
24aiii)	$E = \frac{1}{2}CV^2$ $E = \frac{1}{2} \times 470 \times 10^{-6} \times 250^2$ E = 14.7 J *"Show" question means you've already been given the answer – no mark for this part.*	(1) (1)
24b)	P = E/t $P = 14.7/200 \times 10^{-6}$ P = 73500 W	(1) (1) (1)
24c)	Reduce the value of the resistor. *or* Smaller resistance.	(1)
25a)	 (*Shape*) (*Numbers with origin (zero), units and axis titles*)	(1) (1)
25b)	Electrons are repelled from the negative terminal of the power supply and build up on one side/plate of the capacitor while electrons are attracted away from the other side/plate as they are attracted to the positive terminal of the power supply.	(1)

25c)	V = IR $V = 5 \times 10^{-4} \times 12 \times 10^{3}$ V = 6 V V = 9 - 6 V = 3 V (across the capacitor) C = Q/V $2200 \times 10^{-6} = Q/3$ (*must have used 3 for voltage*) $Q = 6.6 \times 10^{-3}$ C	 (1) (1) (1) (1)
25di)	Stays the same as the supply voltage has not changed.	(1) (1)
25dii)	Decreases as more resistance with the same voltage means a reduced current.	(1) (1)
26a)	C = Q/V $64 \times 10^{-6} = Q/2.5 \times 10^{3}$ Q = 0.16 C *"Show" question means you've already been given the answer – no mark for this part.*	(1) (1)
26b)	$E = ½CV^2$ $E = ½ \times 64 \times 10^{-6} \times (2.5 \times 10^{3})^2$ E = 200 J	(1) (1) (1)
26ci)	V = IR $2.5 \times 10^{3} = 35 \times R$ R = 71.4 Ω	(1) (1) (1)
26cii)	The voltage (across the capacitor) decreases.	(1)
26ciii)	 (*Smaller starting current*) (*Longer time*) (*No labels or not a curving shape means 0 marks*)	 (1) (1)

27ai)	12 V	(1)
27aii)	$E = ½CV^2$ $E = ½ \times 150 \times 10^{-3} \times 12^2$ E = 10.8 J	(1) (1) (1)
27b)	V = IR 12 = I x 75 I = 0.16 A	(1) (1) (1)
27c)	Less time as there will be less energy stored in the capacitor. *or* as there will be less charge stored in the capacitor. *No <u>attempt</u> to justify means 0 marks, even if you said less time, "**must** justify your answer".*	(1) (1)
28a)	V = IR 12 = I x 6800 $I = 1.76 \times 10^{-3}$ A	(1) (1) (1)
28b)	$E = ½CV^2$ $E = ½ \times 220 \times 10^{-6} \times 12^2$ $E = 1.58 \times 10^{-2}$ J	(1) (1) (1)
28c)	Less time as the total resistance in the circuit is less, so a larger charging current. *No <u>attempt</u> to justify means 0 marks, even if you said less time, "**must** justify your answer".*	(1) (1)
29a)	C = Q/V 47×10^{-6} = Q/6 $Q = 2.82 \times 10^{-4}$ C	(1) (1) (1)
29b)	 (*Larger starting current*) (*Less time*) (*No labels or not a curving shape means 0 marks)*	 (1) (1)

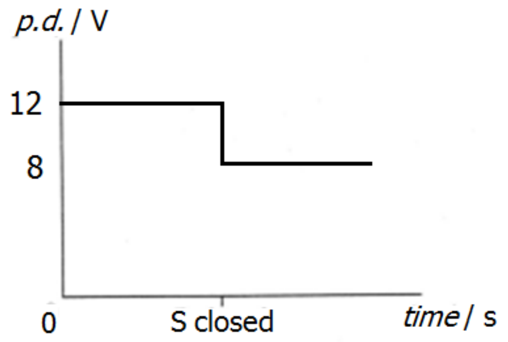
29c)	Increase the supply voltage.	(1)
29d)	**Show teacher if possible.* *Answer could include correct information on similarities such as the car park storing cars where a capacitor stores charge/energy, or the more a car park stores the more difficult it is for new cars to find a place just as how a capacitor storing more charge makes it difficult for more charge to be stored, or how the flow of cars into an empty car park will be greater compared to when it is nearly full just as the flow of charge (current) is greatest when the capacitor isn't storing anything. You could also mention dissimilarities such as cars being able to leave freely whereas charge on a capacitor can only leave when it is being discharged, or that cars are stored inside a car park whereas charge is stored on the plates of a capacitor (not inside it), or that cars can freely enter the car park whereas charge is forced towards a capacitor due to the supply voltage.*	(3)
30.	**Show teacher if possible.* *Answers could include correct information on the maximum charge an ultracapacitor can store compared to an AA rechargeable battery (could do example calculations based on the information given); discuss the internal resistance of power supplies such as rechargeable batteries and how this means the stated voltage of 1.5 V (e.m.f.) is not how much is available to components in the circuit; refer to the possible discharge times of ultracapacitors compared to that of the batteries; could mention how ultracapacitors would initially have a very high discharge current if the resistance in the circuit was low and this may be useful depending on what the ultracapacitor is being used for; could look at equations to work out the maximum energy an ultracapacitor could store.*	(3)

Internal Resistance

1. B   2. B   3. E   4. E   5. D

6ai)	0.508 V	(1)
6aii)	E = V + Ir 0.508 = 0.040 + 2 x r r = 234 Ω	(1) (1) (1)
6b)	The e.m.f. and the internal resistance remain constant. As the total resistance in the circuit has decreased then the current must increase. This means the lost volts (Ir) will increase (so the t.p.d. must decreases). *Could prove through a calculation but needs to be backed up by a correct explanation.*	 (1) (1)
7ai)	4.8 V (*extend the line to the y-intercept*) ± 0.1 V so 4.7 V or 4.9 V are also acceptable.	(1)
7aii)	E = V + Ir 4.8 = 4 + 0.4 x r (*pick any point on the line for V and I values)* r = 2 Ω *The value for E should be whatever you gave as the answer to Q7ai).* *Could be calculated using gradient = -r instead.* *If you've written gradient = r then this is wrong so 0 marks.*	(1) (1) (1)
7bi)	V = IR 12 = I x 0.05 I = 240 A *or* E = V + Ir 12 = 0 + I x 0.05 I = 240 A	(1) (1) (1) *or* (1) (1) (1)
7bii)	E = IR + Ir P = I^2R (*both equations)* 12 = I x 2.5 + I x 0.05 P = $(4.70...)^2$ x 2.5 I = 4.70... A P = 55.4 W	(1) (1), (1) sub. (1) final ans.
8a)	6 J of energy given to each coulomb of charge <u>passing through the supply</u>. *or* 6 J of energy given to each coulomb of charge <u>passing through the battery</u>.	 (1)

8bi)	$E = IR + Ir$ $6 = 200 \times 10^{-3} \times R + 200 \times 10^{-3} \times 2$ $R = 28\ \Omega$ $R = R_1 + R_2$ $28 = 20 + R_2$ $R_2 = 8\ \Omega$ *"Show" question means you've already been given the answer – no mark for this part.*	(1) (1) (1)
8bii)	$E = V + Ir$ $6 = V + 200 \times 10^{-3} \times 2$ $V = 5.6$ V *or* $V = IR$ $V = 200 \times 10^{-3} \times 28$ $V = 5.6$ V	(1) (1) (1) *or* (1) (1) (1)
8c)	When S is closed the total resistance in the circuit decreases meaning the current increases. The lost volts (Ir) will therefore increase so the <u>voltmeter reading</u> (or t.p.d.) <u>will decrease</u>. *Must have correct <u>statement</u> on what happens to the reading on the voltmeter before the mark is awarded for the explanation.*	(1) (1)
9ai)	$E = V + Ir$ $V = IR$ (*both equations*) $9 = 7.8 + I \times 2$ $7.8 = 0.6 \times R$ $I = 0.6$ A $R = 13\ \Omega$	(1) (1), (1) sub. (1) final ans.
9aii)	Current through the internal resistance causes lost volts.	(1)
9b)	When S is closed the total resistance in the circuit decreases meaning the current increases. The lost volts (Ir) will therefore increase so the <u>voltmeter reading</u> (or t.p.d.) <u>will decrease</u>. *Must have correct <u>statement</u> on what happens to the reading on the voltmeter before the mark is awarded for the explanation.*	(1) (1)
10a)	The energy given to each coulomb of charge <u>passing through the supply</u>.	(1)
10biA)	6 V (*extend the line to the y-intercept*) ± 0.1 V so 5.9 V or 6.1 V are also acceptable.	(1)

10biB)	E = V + Ir 6 = 5 + 0.2 x r (*pick any point on the line for V and I values)* r = 5 Ω *The value for E should be whatever you gave as the answer to Q10biA).* *Could be calculated using gradient = -r instead.* *If you've written gradient = r then this is wrong so 0 marks.*	(1) (1) (1)
10c)	V = IR 4.5 = 0.3 x R (*read the voltage on the graph when I = 0.3 A*) R = 15 Ω *"Show" question means you've already been given the answer – no mark for this part.*	(1) (1)
11a)	12 V	(1)
11bi)	E = V + Ir 12 = 9.6 + I x 2 I = 1.2 A	(1) (1) (1)
11bii)	V = IR 9.6 = 1.2 x R R = 8 Ω	(1) (1) (1)
11c)	 (*12 value and straight line*) (*8 value and straight line*) (*$1/R = 1/R_1 + 1/R_2$* *1/R = 1/8 + 1/8* *R = 4 Ω* *E = IR + Ir* *12 = I x 4 + I x 2* *I = 2 A* *V = IR* *V = 2 x 4* *V = 8 V*)	 (1) (1)

12ai)	$R_t = R_1 + R_2 + R_3$ $R_t = 0.2 + 0.2 + 3.6$ R_t = <u>4 Ω</u>	 (1)
12aii)	E = IR + Ir 3 = I x 3.6 + I x 0.4 I = 0.75 A *or* V = IR 3 = I x 4 I = 0.75A	(1) (1) (1) *or* (1) (1) (1)
12aiii)	$P = I^2R$ $P = 0.75^2 \times 3.6$ P = 2.03 W *Or consistent with the value for current determined in 12aii).*	(1) (1) (1)
12b)	It will decrease as the total resistance increases so the current decreases. The resistance of the heating element is the same so the power will decrease ($P = I^2R$).	(1) (1)
13ai)	V = IR V = 3 x 1.5 (*read the current on the graph when R = 1.5 Ω*) V = 4.5 V (across the variable resistor) Lost volts = 6 - 4.5 (*if missed but final answer is 1.5 V then full marks)* Lost volts = 1.5 V	 (1) (1) (1) (1)
13aii)	Lost volts = Ir 1.5 = 3 x r r = 0.5 Ω	(1) (1) (1)
13b)	The lost volts will decrease as the total resistance increases meaning less current. If the internal resistance is the same then the lost volts will decrease (lost volts = Ir). *No <u>attempt</u> to justify means 0 marks, even if you said it will decrease, "**must** justify your answer".*	(1) (1)
14ai)	10 J of energy given to each coulomb of charge <u>passing through the supply</u>.	 (1)
14aii)	E = V + Ir 10 = 7.5 + 1.25 x r r = 2 Ω *"Show" question means you've already been given the answer – no mark for this part.*	(1) (1)

14bi)	The total resistance has decreases meaning the current increases. As the internal resistance is constant then the lost volts (Ir) will increase so the voltmeter reading (t.p.d.) has decreased.	(1) (1)
14bii)	$E = IR + Ir$ $1/R = 1/R_1 + 1/R_2$ (*both equations*) $10 = 2 \times R + 2 \times 2$ $1/3 = 1/6 + 1/R_2$ $R = 3\ \Omega$ $R_2 = \underline{6\ \Omega}$	(1) (1), (1) sub. (1) final ans.
15ai)	$E = IR + Ir$ $12 = I \times 6 + I \times 2$ $I = 1.5$ A	(1) (1) (1)
15aii)	Lost volts = Ir Lost volts = 1.5 x 2 Lost volts = <u>3 V</u>	 (1)
15aiii)	$P = I^2R$ $P = 1.5^2 \times 6$ $P = 13.5$ W	(1) (1) (1)
15b)	It is less than as if the resistance of the bulb is constant then the current must increase to increase the power. Therefore, the total resistance in the circuit must have decreased (due to internal resistance being less). *No <u>attempt</u> to justify means 0 marks, even if you said it will decrease, "**must** justify your answer".*	(1) (1)
16ai)	12 V (*extend the line to the y-intercept*)	
16aii)	$E = V + Ir$ $12 = 7 + 200 \times r$ (*pick any point on the line for V and I values)* $r = 0.025\ \Omega$ *The value for E should be whatever you gave as the answer to Q16ai).* *Could be calculated using gradient = -r instead.* *If you've written gradient = r then this is wrong so 0 marks.*	(1) (1) (1)
16aiii)	$V = IR$ $12 = I \times 0.025$ $I = 480$ A *or* $E = V + Ir$ $12 = 0 + I \times 0.025$ $I = 480$ A	(1) (1) (1) *or* (1) (1) (1)

16b)	The total resistance in the circuit decreases causing the current to increase. This causes the lost volts (Ir) to increase as the internal resistance is constant, so less voltage across the headlight (meaning dimmer).	(1) (1)
17ai)	$E = IR + Ir$ $\quad$ $R = R_1 + R_2$ $\quad$ (*both equations*) $4.5 = 0.3 \times R + 0.3 \times 0.5$ $\quad$ $14.5 = R_1 + 2.5$ $R = 14.5\ \Omega$ $\quad$ $R_1 = 12\ \Omega$ *"Show" question means you've already been given the answer – no mark for this part.*	(1) (1), (1) sub.
17aii)	$P = I^2R$ $P = 0.3^2 \times 12$ $P = 1.08$ W	(1) (1) (1)
17bi)	3.5 V	(1)
17bii)	$E = V + Ir$ $4.5 = V + 200 \times 10^{-3} \times 0.5$ $V = 4.4$ V $V = V_1 + V_2$ $4.4 = V_1 + 3.5$ $V_1 = 0.9$ V	(1) (1) (1) (1)
17c)	Electrons and holes combine at the (p-n) junction causing photons to be emitted.	(1) (1)
18ai)	12.8 J of energy given to each coulomb of charge passing through the supply.	(1)
18aii)	$E = IR + Ir$ $12.8 = I \times 0.05 + I \times 6 \times 10^{-3}$ $I = 229$ A	(1) (1) (1)
18aiii)	It has a low resistance. *or* To prevent overheating. *or* To prevent wires from melting.	(1)
18bi)	12.6 V *No tolerance, must be exactly this value.*	(1)
18bii)	$E = V + Ir$ $12.6 = 12.2 + 40 \times r$ $\quad$ (*pick any point on the line for V and I values)* $r = 0.01\ \Omega$ *The value for E should be whatever you gave as the answer to Q18bi).* *Could be calculated using gradient = -r instead.* *If you've written gradient = r then this is wrong so 0 marks.*	(1) (1) (1)

19ai)	V = IR V = 1.8 x (4.8 + 0.1) V = 8.82 V (12.8 – 8.82) Voltmeter reading = <u>3.98 V</u> *Other suitable methods to reach the <u>same final answer</u> are acceptable.*	(1) (1) (1) (1)
19aii)	It decreases as the total resistance in the circuit decreases so the current increases. This increases the lost volts (Ir) as internal resistance is constant meaning less voltage available for the rest of the circuit/meaning the t.p.d decreases.	(1) (1) (1)
19bi)	Electrons move away from n-type towards the junction. Electrons in the conduction band combine with holes in the valence band. This causes photons to be emitted.	(1) (1) (1)
19bii)	E = hf v = fλ (*both equations)* $3.03 \times 10^{-19} = 6.63 \times 10^{-34} \times f$ $3 \times 10^{8} = 4.57… \times 10^{14} \times \lambda$ $f = 4.57… \times 10^{14}$ Hz $\lambda = 6.56 \times 10^{-7}$ m	(1) (1), (1) sub. (1) final ans.
20a)	1.5 J of energy given to each coulomb of charge <u>passing through the supply</u>.	 (1)
20bi)	Lost volts = Ir Lost volts = $64 \times 10^{-3} \times 5.4$ Lost volts = 0.35 V *or* V = IR V = $64 \times 10^{-3} \times 5.4$ V = 0.35 V *"Show" question means you've already been given the answer – no mark for this part.*	(1) (1) *or* (1) (1)
20bii)	(3 – 0.35) V = <u>2.65 V</u>	 (1)
20biii)	P = IV P = $64 \times 10^{-3} \times 2.65$ P = 0.17 W	(1) (1) (1)

20c)	$E = V + Ir$ * (**both equations*) $6 = V + 26 \times 10^{-3} \times 10.8$ $V = 5.7192$ $V = V_1 + V_2$ $5.7192 = V_1 + 3.6$ $V_1 = 2.1192$ V $V = IR$ * $2.1192 = 26 \times 10^{-3} \times R$ R = <u>81.5 Ω</u> *Other suitable methods to reach the <u>same final answer</u> are acceptable.*	(1) (1) sub. (1) sub. (1) final ans.
21a)	The energy given to each coulomb of charge <u>passing through the supply</u>.	(1)
21b)	$E = V + Ir$ $670 \times 10^{-3} = 400 \times 10^{-3} + 75 \times 10^{-6} \times r$ (*pick any point on the line for V and I values)* r = 3600 Ω *The value for E should be whatever you gave as the answer to Q18bi).* *Could be calculated using gradient = -r instead.* *If you've written gradient = r then this is wrong so 0 marks.*	(1) (1) (1)
22ai)	1.5 V	(1)
22aii)	$E = V + Ir$ $1.5 = 1.3 + 0.88 \times r$ r = 0.227 Ω *E value should be consistent with your answer to Q22ai).*	(1) (1) (1)
Q22aiii)	When the switch is closed there is a current in the circuit. Due to internal resistance there will be lost volts (Ir) (meaning less t.p.d/meaning the reading on the voltmeter decreases).	(1) (1)
Q22bi)	$E = IR + Ir$ $9 = I \times 2.4 + I \times 1.2$ I = 2.5 A	(1) (1) (1)
Q22bii)	$P = I^2R$ $P = 2.5^2 \times 2.4$ P = 15 W	(1) (1) (1)

Oscilloscopes and A.C. Supplies

1. A	2. E	3. E	4. E	5.D	6.B
7. C	8. D	9. E	10. D	11. A	12. A
13. B					

14ai)	period = $4 \times 2.5 \times 10^{-3}$ period = 1×10^{-2} s $T = 1/f$ $1 \times 10^{-2} = 1/f$ $f = 100$ Hz	 (1) (1) (1)
14aii)	$V_{peak} = 2 \times 5$ $V_{peak} = 10$ V $V_{rms} = V_{peak}/\sqrt{2}$ $V = IR$ (*both equations*) $V_{rms} = 10/\sqrt{2}$ $7.07... = I \times 200$ $V_{rms} = 7.07...$ V I = <u>0.0354 A</u>	 (1) (1) (1) both sub. (1) final ans.
14b)	Only showing half cycles as the diode only conducts with current flowing one way.	(1) (1)
15a)	Peak voltage = 3×0.5 Peak voltage = 1.5 mV	 (1)
15b)	Period = 4×1 Period = 4 ms $T = 1/f$ $4 \times 10^{-3} = 1/f$ $f = 250$ Hz	 (1) (1) (1)
16ai)	Peak voltage = 4×0.5 Peak voltage = 2 V	 (1)
16aii)	Period = 5×2 Period = 10 ms $T = 1/f$ $10 \times 10^{-3} = 1/f$ $f = 100$ Hz	 (1) (1) (1)
16b)	Unchanged.	(1)
16c)	The amplitude <u>halves</u>/ The height of the wave <u>halves</u>. *Need to be specific, can't just say it gets smaller.*	(1)

17a)	Period = 4 x 0.01 Period = 0.04 s T = 1/f 0.04 = 1/f f = 25 Hz	 (1) (1) (1)
17b)	$V_{rms} = V_{peak}/\sqrt{2}$ $2.3 = V_{peak}/\sqrt{2}$ V_{peak} = 3.25 V	(1) (1) (1)
17ci)	<u>Twice</u> as many waves on the screen. *Need to be specific, can't just say more waves.*	(1)
17cii)	Unchanged as the voltage and the resistance are unchanged. *or* as the current does not depend on the frequency.	(1) (1) *or* (1)
18ai)	Peak voltage = 3 x 0.2 Peak voltage = 0.6 V	 (1)
18aii)	$V_{rms} = V_{peak}/\sqrt{2}$ V = IR (*both equations*) $V_{rms} = 0.6/\sqrt{2}$ 0.424… = I x 1 x 10^3 V_{rms} = 0.424… V I = <u>4.24 x 10^{-4} A</u>	(1) (1), (1) sub. (1) final ans.
18aiii)	($R_t = R_1 + R_2$ R_t = 1 x 10^3 + 2.2 x 10^3 R_t = 3.2 x 10^3 Ω) V = IR V = 4.24 x 10^{-4} x 3.2 x 10^3 V = 1.36 V	 (1) (1) (1)
18b)	Greater than as it has a larger voltage across it due to having a higher resistance. *Could prove by calculation that it has a larger voltage.*	(1) (1)
19ai)	Peak voltage = 3 x 1 Peak voltage = 3 V	 (1)
19aii)	Period = 4 x 0.5 Period = 2 s T = 1/f 2 = 1/f f = 0.5 Hz	 (1) (1) (1)

19aiii)	The LEDs will light when they are forward biased. *or* The LEDs will only conduct in one direction. The negative and positive represent the current (or voltage) travelling in opposite directions.	(1) *or* (1) (1)
19b)	$V_1 = \left(\frac{R_1}{R_1 + R_2}\right) V_s$ $V_1 = \left(\frac{82}{68 + 82}\right) \times 3$ $V_1 = 1.64$ V $V_{rms} = V_{peak}/\sqrt{2}$ $V_{rms} = 1.64/\sqrt{2}$ $V_{rms} = 1.16$ V *Other suitable methods to get the same answer with units is acceptable.*	(1) (1) (1) (1) (1)